US ADMINISTRATION

Comparison of Radiated Emission Spectra of Maritime Radiolocation Radars with Varying Distances from the Measurement System in the Bands 2 900-3 100 MHz and 8 500-10 500 MHz

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Introduction.

Emission spectra of radiolocation radars may be measured via direct radiation from the transmitter antenna. For radiated emission measurements on a radar, it is important to position the measurement system so that maximum power is coupled from the radar to the measurement system. This condition will achieve the highest possible dynamic range in the resulting emission spectrum data.

The question of near field and far field distances inevitably arises for radiated measurements. The terms 'near field' and 'far field' refer to changes in the radiation patterns of antennas as a function of distance from such antennas. Antenna patterns gradually approach a limiting case at infinite distances, but real-world measurements must be performed at finite distances. Therefore criteria have been developed for computation of distances at which radiation patterns are close enough to the limiting case to satisfy most engineering and scientific requirements. Two common criteria are $2D^2/\lambda$ and D^2/λ, where D is the antenna diameter and λ is the wavelength of the radiation. But as noted, these criteria are intended for use in radiation pattern measurements, not spectrum measurements.

However, the far field distance requirement that is necessary for measurement of uncorrected antenna patterns is not necessarily a requirement for emission spectrum measurements. This document describes the results of a study that compared the emissions of 3 GHz and 9 GHz maritime radars when the measurement distances were varied between the far-field distance and shorter ranges.

If the far-field limit is taken as D^2/λ, then for a 2 900-MHz radar with a 7-m antenna diameter, for example, the far-field distance will be 475 m. For a 420 MHz radar with an antenna diameter of 40 m, the far-field distance will be 2.25 km.

Antenna pattern measurements within the near field limit will be incorrect. Thus a distance of D^2/λ or greater is preferred when the measurement system is being positioned for an antenna pattern measurement.

Experimental Setup.

Radiated emission spectrum measurements were performed at an outdoor radio measurement facility, in the Table Mountain radio quiet zone north of Boulder, Colorado in the US on two maritime radars, one with a fundamental operating frequency in the 2 900-3 100 MHz band ("S-Band Radar 1") and the other with a fundamental operating frequency in the 8 500-10 500 MHz band ("X-Band Radar 6"). The S-Band Radar 1 was provided by the Administration of Japan and was measured jointly by the Administrations of Japan and the US. The X-Band Radar 6 was property of the US Administration. Both radars were measured in accordance with the Direct Method of ITU-R M.1177. The measurement system block diagram is shown in Figure 1.

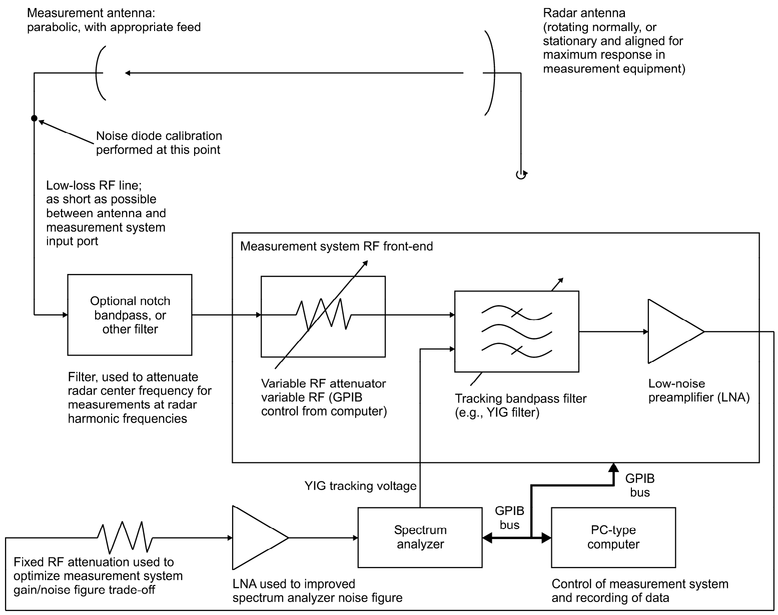

Figure 1. Block diagram of measurement system used for radar emission spectrum measurements.

The distances between the measurement antenna and the radars, the spectrum analyzer models that were used, and the measurement bandwidths are shown in Table 1. All parameters except distance between the measurement antenna and transmitter antenna were held constant during measurements for each radar model. Table 2 contains pertinent characteristics of the two radars.

Table 1. Measurement distances, spectrum analyzer models, and measurement bandwidths used for emission spectrum measurements in this study.

Radar	**Distances between radar and measurement antenna (m)**	**Spectrum analyzer model**	**Measurement bandwidth (MHz)**
S-Band Radar 1	366 (=2 D^2/λ) 96 (=0.26 D^2/λ)	HP-8566B	3
X-Band Radar 6	105 (=D^2/λ) 65 (=0.62 D^2/λ)	Agilent E4440A	1

Table 2. Selected characteristics of radars in this study.

Radar Designator	**Pulse width (μs)**	**Output device**	**Antenna type**	**Antenna length (m)**
S Band Radar 1	0.06	magnetron	end fed slotted array	4.3
X Band Radar 6	0.08 and 0.8	magnetron	end fed slotted array	1.8

Measurement Results.

The emission spectrum measurement results for the varying distances between the measurement and transmitter antennas are shown in Figures 2-3.

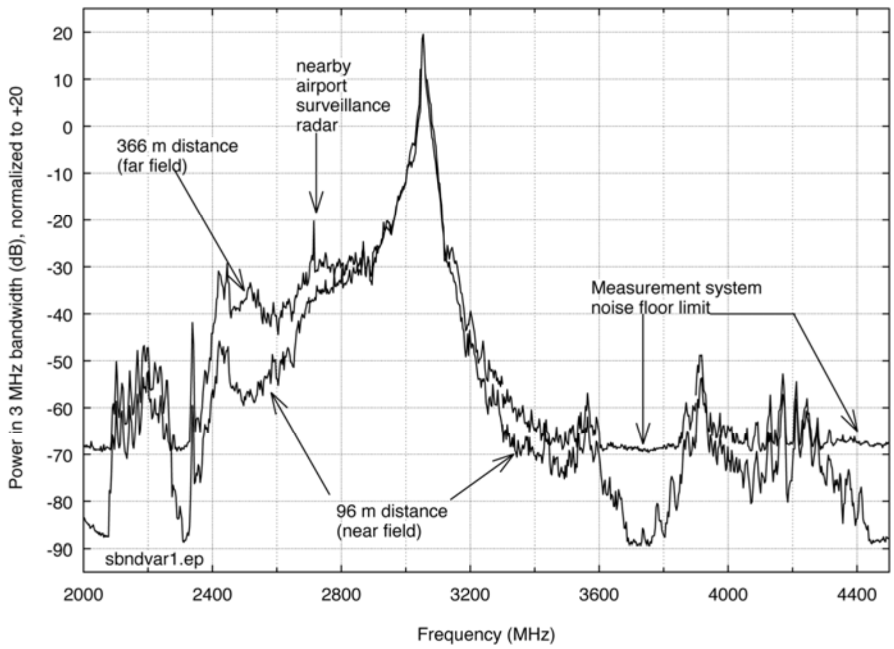

Figure 2. Emission spectrum measurements of a maritime radar made at distances of 366 m (2 D^2/λ distance limit) and 96 m. Where measurements are shown below the measurement system noise floor (near 2 000, 2 300, 3 700, and 4 300-4 500 MHz), the data are from the near field measurement.

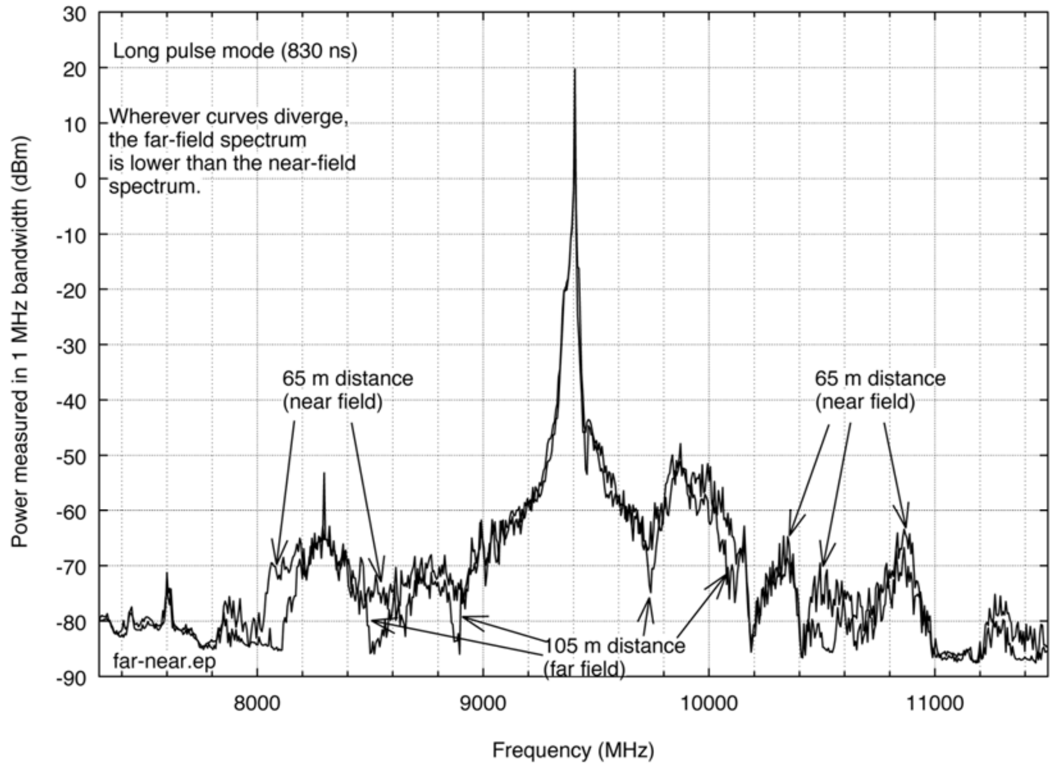

Figure 3. Emission spectrum measurements of a maritime radar made at distances of 105 m (D^2/λ distance limit) and 65 m. Where the two spectra diverge, the far-field spectrum is lower than the near-field spectrum.

The results of emission spectrum measurements in the near field versus the far field are mostly very similar, but there are isolated regions within each spectrum where the results diverge by up to 20 dB for S-Band Radar 1 and up to 10 dB for X-Band Radar 6.

Conclusion.

For the most part, emission spectrum measurements of non-harmonic emissions are the same for distances that are less than the far field versus distances that are at or beyond far field. However, some divergence of up to 20 dB may occur in localized parts of the spectra as the measurement distance is varied. Given that antenna patterns must be measured at or beyond the far field limit (at least D^2/λ), a practical arrangement is to perform the spectrum measurements at the same distance. In cases in which additional measurement dynamic range is required to verify emission mask compliance, the sensitivity of the measurement system should be increased, rather than simply moving the measurement system closer to the radar.